Patoka River Basin 1996 Statistical Analysis

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Contents

List of Tables

List of Figures

List of Plates

Abstract

Surface water quality data from the 1996 synoptic study of the Patoka River Watershed were statistically analyzed to determine: background levels at particular sampling stations; if these stations fit within normal background levels for the various seasons; and how land use affects the chemical parameters. Summary statistics were calculated for eight focal parameters at the sampling stations to establish benchmark data. A classification system was created based on a quartile system of overall observations to classify streams on the Patoka River and tributary streams as High, Upper Background, Lower Background, or Low. The classifications were then plotted on land use maps to determine how specific areas affected stream chemistry, and how water quality changed from station to station. Seasonal parameter levels and outliers were also examined.

Introduction

This document is a statistical analysis of the 1996 synoptic study of the Patoka River Watershed. The 1996 synoptic study of the Patoka River Watershed was conducted by the Indiana Department of Environmental Management's Water Surveys Section to fulfill requirements of the Clean Water Act. The project's goals were to provide benchmark data for long term trend analysis along with a comprehensive look at surface water quality in the basin. The data were also examined relative to surface water quality standards to identify emerging problems. During the course of the project, each station in the study area was sampled approximately six times. These stations were selected, named, and sampled within the agency's defined protocols for the project (Indiana Department of Environmental Management 1998). This statistical analysis focuses on the chemical parameters that were important to the project. These include nutrients:

- total organic carbon (TOC),
- total phosphorus, and
- total Kjeldahl nitrogen (TKN);

and general chemistry parameters:

- alkalinity,
- dissolved solids,
- sulfate,
- hardness, and
- chloride.

The department's intent is to revisit this watershed in 2001 to determine if changes have occurred or new problems have developed. To facilitate this goal, the background levels for the stations need to be determined for the various parameters. Land-use and seasonality also need to be considered in the evaluation because of the intrinsic dynamic nature of aquatic systems, and the impact the watershed can have on stream chemistry.

To reach this end, this document will answer the following questions:

- What are the normal background levels within the Patoka River Watershed for eight chemical parameters at a given station?
- Does the data from these stations fit within the normal levels expected for the various seasons?
- How does land use affect the chemical concentrations that have been observed?

The Study Area

The area that was sampled in this study was the Patoka River Watershed. This watershed is south of both the East Fork and West Fork White River Basins. It extends from the Illinois border to Orange and Dubois Counties. Specifically, the USGS hydrologic unit code defines the watershed as HUC 05120209. Appendix A lists the stations' locations, waterbodies, counties, and 11 digit hydrologic unit codes.

Materials and Methods

Computer programs were used extensively for the statistical analysis. To accomplish the analysis, the data were evaluated using the STATISTICA Release 5 statistical program and the Paradox 8.0 database program. The Arcview Geographic Information System (GIS) was used for the maps of the watershed found within this document.

Background Levels

The first task was to evaluate the station's data to determine background levels. These background levels were determined by calculating a battery of statistics which describe the shape, spread, and central tendency of the observations. The statistics that were calculated for each station and parameter were: average, median, mode, geometric mean, variance, standard deviation, standard error, minimum, maximum, range, lower quartile, upper quartile, interquartile range, skewness, standardized skewness, kurtosis, standardized kurtosis, coefficient of variation, and sum. Narrative explanations and formulas for these terms are found in Appendix B.

Classifications and Land Use

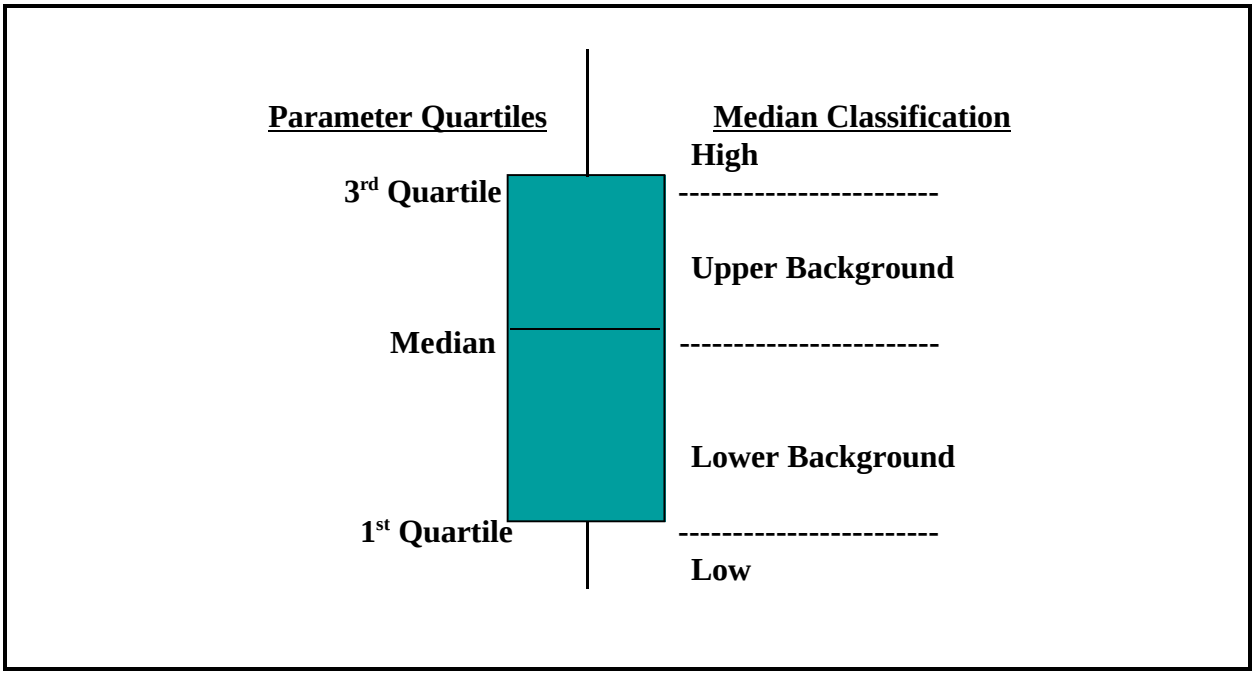
The next tasks were to classify the water chemistry of these stations relative to each other and to compare the classification to land usage in the watershed. The stations were separated into two different sets for evaluation. These two sets were stations located directly on the Patoka River and stations that were located on tributary streams.

For the set of Patoka River stations and the set of tributary stations, the observations for each parameter were compiled. The median, first, and third quartiles for the compiled sets for each parameter were determined. These ranges were then compared to every individual station's median value to classify the station's typical parameter level (see Figure 1). In this analysis, the median was preferable to the average due to the small number of observations and outlying values which could be caused by seasonality and atypical events in the watershed such as rainfall.

Stations were classified by comparing their median concentrations to the appropriate compiled set. When a station's median value was greater than the upper quartile range of the compiled set,

it was classified as “high”. When a station had a median value that was greater than the median of the compiled set and less than or equal to the upper quartile of the compiled group, it was classified as “upper background”. When a station had a median value that was less than or equal to the median of the compiled set, and greater than or equal to the lower quartile of the compiled set, it was classified as “lower background”. When a station had a median value that was less than the lower quartile of the compiled set, it was classified as “low”. This information was then plotted onto maps which showed both streams and land use. By doing so, inferences could be made on how the watershed was affecting median (typical) chemical concentrations.

Figure 1. Graphical representation of how the classifications were produced for each of the parameters to classify station medians.



For example, the compiled tributary stream data had an alkalinity median of 53.5 mg/l, an upper quartile value of 86.0 mg/l, and a lower quartile value of 42.0 mg/l. Station 55-02 had a median value of 73.0 mg/l. As a result, this station was classified as being in the upper background range for alkalinity. As an additional example, station 55-01 had an alkalinity median value of 44.0 mg/l. This station was classified in the lower background range for alkalinity.

Seasons and Outliers

Next, all of the observations for each parameter were compiled and divided into four seasons. These four seasons were spring: March, April, and May; summer: June, July, and August; fall: September, October, and November; and winter: December, January, and February. The

median and quartile values for the watershed were computed for each season and parameter to determine typical seasonal levels found within the watershed. Special attention was placed on stations which had outliers more than once (these will be referred to as chronic outliers) for a given parameter. Stations that had chronic outliers for a given parameter were compared to how the stations had been previously classified based on their median score for that parameter.

Results and Discussion

Station Background Levels

Summary statistics were calculated for each station to define benchmark levels.. The results of these computations are lengthy, so they have been listed in Appendix C. The information that these statistics provide will be useful to IDEM when the watershed is revisited in the year 2001.

The statistics can be used to create a picture of the background levels for each parameter at each station. More data points would be preferable in the evaluation as it would increase the statistical power (increase kurtosis) and decrease the standard deviation. Additionally, the stations were sampled regardless of the weather conditions. As a result, some of the observations had elevated parameters which may be due to runoff from the watershed. This results in data that does not necessarily reflect the typical background levels for the stream.

When posed with questions about background levels, people generally want to know what the levels for the various parameters would be if they were to sample the station. The best way to answer this question is to examine the data's median, mean, interquartile range, standard deviation and skewness.

The median and mean are used to describe the most typical value for a given parameter. Ideally, the median value should approximate the mean. However, outliers that are due to anomalous events can result in elevated results for the parameters, moving the mean from the median. When the absolute value of the skewness is close to zero, the data are close to being evenly distributed on either side of the mean. In this case, the mean is a good approximation of the most typical value. When outliers are affecting the mean of the data set, the median is a better estimate of the most typical concentration for the parameter.

For example, the total phosphorus observations for station 26-06 had an average of 0.20 mg/l and a median of 0.195 mg/l. The skewness was also very close to zero, at 0.331. The conclusion from this information is that the median approximates the mean well, and the observations are evenly distributed around the mean.

A range of expected values for each parameter is also important when describing background levels for each of the stations. Two different statistical elements can be used to define this range.

These are the inter-quartile range and the standard deviation. The interquartile range is bounded by the upper quartile and lower quartile values. This range describes where 50% of the observations were measured. Hence, if the station was resampled, it would be expected that any given sample would fit within this range 50% of the time. However, since each station was only sampled about six times, this is not a statistically powerful statement.

The standard deviation can also be used to predict where typical levels for parameters can be found. Roughly two-thirds of the observations should be measured within 1 standard deviation of the mean. However, if the mean is small, the standard deviation could overlap into negative values. Of course, negative parameter values are not possible, so the conclusion would need to be truncated at zero.

For example, station 26-08 had an mean alkalinity of 50.1 mg/l. The interquartile range was bounded by a low value of 38.0 mg/l, and a high value of 60.0 mg/l. In other words, half of the observations were between 38.0 and 60.0 mg/l. If the samples were representative of the station's typical values, it would be expected that another sample taken at this station would be within this range 50% of the time. The standard deviation was 11.50 mg/l. In a normal distribution roughly 2/3 of the observations are within 1 standard deviation of the mean. So, if the samples are representative of the true population, 2/3 of the values should be between 38.7 mg/l and 61.7 mg/l.

Classifications and Land Use

The data for each of the stations that were directly located on the Patoka River were compiled into a set for classification. The compiled data for each parameter were then sectioned into quartiles as described in the methods section. This resulted in the following classifications for the eight parameters.

Table 1. Classifications ranges for Patoka River stations based on quartiles.

Parameter	Low	Lower Background	Upper Background	High
Alkalinity (mg/l)	< 44.0	44.0 to 57.5	57.6 to 68.0	> 68.0
Total Phosphorus (mg/l)	< 0.05	0.05 to 0.14	0.15 to 0.22	> 0.22
Dissolved Solids (mg/l)	< 100	100 to 170	171 to 230	> 230
Sulfate (mg/l)	< 20.0	20.0 to 37.5	37.6 to 90.0	> 90.0
Total Kjeldahl Nitrogen (mg/l)	< 0.68	0.68 to 0.98	0.99 to 1.60	> 1.60
Total Organic Carbon (mg/l)	< 2.8	2.8 to 3.25	3.26 to 5.3	> 5.3
Hardness (mg/l $CaCO_3$)	< 75.0	75.0 to 94.0	75.1 to 140.0	> 140
Chloride (mg/l)	< 3.6	3.6 to 5.2	5.3 to 8.5	>8.5

The stations were plotted on GIS maps which include land use, county lines, and major highways. For each parameter, each station was assigned a color coded point to indicate the classification. These maps are included in this report as *plates 1-8.*

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Examination of the maps reveals forest as the predominate land use with some urban areas, agriculture, and strip mines. Although the discussion of stations and land use could be lengthy and repetitive, there are a few specific points worth mentioning

Total phosphorus and TOC concentrations gradually increased as the water moved from up to down stream along the Patoka River (*see plates 7 and 8)*. TOC was classified as high at station 54-02A. This may be the result of cumulative inputs of organic carbon throughout the watershed and runoff from the surrounding forested areas. Total phosphorus was classified as high at stations 54-02A and 54-02. However, station 26-08 was also classified as high for total phosphorus. This station may have high concentrations of total phosphorus due to inputs from the cities of Jasper and Huntingburg, and agricultural runoff. Therefore, the elevated total phosphorus at stations 54-02 and 54-02A are probably not due to contributions from the forested areas.

Hardness and dissolved solids had the same classification pattern from stations 54-02A to 54-03 to 54-05 (*see plates 3 and 4*). For both parameters, the hardness and dissolved solids increased in classification from lower background to upper background to high, respectively. This pattern is probably due to influences from agricultural runoff and strip mine drainage.

The data for the tributary stations were likewise compiled into data sets and classified into high, upper background, lower background, and low categories. These categories are described on Table 2.

Table 2. Classification Ranges for Patoka Tributary Stations Based on Quartiles.

Parameter	Low	Lower Background	Upper Background	High
Alkalinity (mg/l)	<42.0	42.0 to 53.5	53.6 to 86.0	> 86.0
Total Phosphorus (mg/l)	< 0.63	0.63 to 0.135	0.136 to 0.23	> 0.23
Dissolved Solids (mg/l)	< 185	185 to 265	266 to 790	> 790
Sulfate (mg/l)	< 45.0	45.0 to 79.5	79.6 to 450.0	> 450.0
Total Kjeldahl Nitrogen (mg/l)	< 0.81	0.81 to 1.25	1.26 to 2.00	>2.00
Total Organic Carbon (mg/l)	< 2.65	2.65 to 3.95	3.96 to 5.45	> 5.45
Hardness (mg/l $CaCO_3$)	< 110	110 to 130	131 to 540	> 540
Chloride (mg/l)	< 10.3	10.3 to 13.0	13.1 to 18.0	> 18.0

The parameters for the stations on tributary streams can be compared to the land use which drains into the waterbody. Notable facts are discussed below.

Station 26-07 was classified as high for total phosphorus, TOC, and TKN. This is probably due to agricultural runoff and possibly due to contributions from Huntingburg. Likewise, station 54-04 was classified as high for TOC and total phosphorus. This is probably due to agricultural runoff.

Strip mine runoff probably had a large influence on two of the stations. Station 55-01 had high classifications for dissolved solids, hardness, and sulfate. Station 55-02 was also classified as high for sulfate. Both of these stations' drainage areas contain strip mines, allowing for mineral runoff, and pyrite (FeS_2) oxidation into sulfuric acid (H_2SO_4).

Conversely, station 54-01 is not downstream of any strip mines. This station had a high classification for alkalinity. It is probable that sulfuric acid was not available to combine with the ions, contributing to alkalinity.

The results of the chloride classifications revealed an interesting paradox (*see plate 2*). Station 26-04 had a low classification for chloride while station 26-05 had a high classification. These stations are in adjacent drainage areas and appear to have highly similar land use. The cause of

this discrepancy are not explainable with the current information available and will require further field study to explain.

Seasons and Outliers

The median and quartile values were computed for each of the four seasons using all of the data gathered in the study. The upper and lower quartiles indicate the range where 50% of the observations throughout the watershed were measured during that particular season. The median, upper, and lower quartile levels are listed in the following tables for each parameter. Appendix D contains seasonal Box-Whisker plots for the parameters.

Table 3. Spring Parameters

Parameter	Lower Quartile	Median	Upper Quartile
Alkalinity (mg/l)	37.5	48.0	57.5
Total Phosphorus (mg/l)	0.054	0.17	0.25
Dissolved Solids (mg/l)	160	215	280
Sulfate (mg/l)	36.5	70	160
Total Kjeldahl Nitrogen (mg/l)	0.65	1.35	2.2
Total Organic Carbon (mg/l)	2.75	3.85	6.35
Hardness (mg/l $CaCO_3$)	79.5	115	150
Chloride (mg/l)	5.45	10.2	15.0

Table 4 . Summer Parameters

Parameter	Lower Quartile	Median	Upper Quartile
Alkalinity (mg/l)	46.0	64	90.5
Total Phosphorus (mg/l)	0.059	0.15	0.195
Dissolved Solids (mg/l)	145	190	550
Sulfate (mg/l)	29	50	220
Total Kjeldahl Nitrogen (mg/l)	0.85	1.0	1.3
Total Organic Carbon (mg/l)	2.05	3.35	4.45
Hardness (mg/l $CaCO_3$)	82	120	325
Chloride (mg/l)	4.8	7.8	11

Table 5. Fall Parameters

Parameter	Lower Quartile	Median	Upper Quartile
Alkalinity (mg/l)	66	72	110
Total Phosphorus (mg/l)	0.05	0.11	0.17
Dissolved Solids (mg/l)	100	190	322
Sulfate (mg/l)	19	48	130
Total Kjeldahl Nitrogen (mg/l)	0.81	1.00	1.40
Total Organic Carbon (mg/l)	2.8	2.9	3.2
Hardness (mg/l $CaCO_3$)	81.5	120	225
Chloride (mg/l)	4.4	7.5	20.0

Table 6. Winter Parameters

Parameter	Lower Quartile	Median	Upper Quartile
Alkalinity (mg/l)	40	42.0	58.0
Total Phosphorus (mg/l)	0.091	0.15	0.33
Dissolved Solids (mg/l)	160	190	320
Sulfate (mg/l)	44	48	120
Total Kjeldahl Nitrogen (mg/l)	0.68	1.10	1.60
Total Organic Carbon (mg/l)	2.7	5.1	7.6
Hardness (mg/l $CaCO_3$)	86	100	180
Chloride (mg/l)	8.6	9.9	13.0

Two of the nutrients, total phosphorus and TKN, had the highest typical concentrations in the spring. This reflects spring runoff of accumulated materials and the application of fertilizers in the watershed. TOC concentrations were typically higher in the winter. This could be the result of foliage decomposition from the fall deposition of leaves and agricultural runoff after harvest. Dissolved solids, hardness, and sulfate were typically highest in the summer months which may reflect the runoff of minerals in the watershed during high flow conditions. Although high levels of dissolved solids and hardness often are mirrored by high alkalinity, this was not the case during the summer months. Although there were high levels of dissolved solids and hardness during the

summer, the high sulfate levels and low alkalinity indicate acid mine drainage in the form of sulfuric acids.

Many factors can affect these parameter levels. Typically rainfall and watershed activities can cause an elevated level for parameters. These anomalies will typically appear as outliers on box-whisker plots. These outliers can then be used as a tool to determine if the stations fit within the expected levels for the various seasons.

Because of the dynamic nature of chemical parameters in streams, and the varying weather conditions under which the stations were sampled, the importance of these outliers can be evaluated when a station has outlying observations more than once for a given parameter. In other words, roughly one-third or more of the observations for a given parameter at a station were outliers when compared to the watershed as a whole. These were previously defined as stations which had chronic outliers for a given parameter. The chronic outliers are indicative of stations which do not conform to the expected background levels. Table 7 lists the stations and their land use. The various parameters which were chronic outliers are identified by their classification. For example, station 26-01 had the chronic outlying parameter of alkalinity. This is indicated in Table 7 as an "H" for high classification is in the cell for the station and parameter. Blank cells in the table indicate that the parameter was not a chronic outlier for that specific station.

Table 7. Stations, Land Use, and Parameters which were chronic outliers noted by their classification.

Station	Land Use	Alkalinity	Dissolved Solids	Sulfate	TKN	TOC	Hardness	Chloride
26-01	Agricultural	H						
26-06	Agricultural							H
26-07	Agricultural				H			UB
54-01	Agricultural/ Forest							
54-04	Agricultural/ Forest		UB			H		
55-01	Agricultural/ Forest		H	H			H	
55-02	Agricultural/ Forest		H	H			H	

Note for Classifications: H is High, UB is Upper Background, LB is Lower Background, and L is Low.

Intuitively, the expectation is that sites which had chronic outliers for a given parameter would be classified as being in the high range. This was often the case. All of the stations that had chronic outliers for alkalinity, sulfate, TKN, TOC, and hardness had been classified in the high range. Two stations did not follow this pattern. Station 54-04 was classified as upper background for dissolved solids. Station 26-07 was classified as upper background for chloride. As a final note, there were no chronic outliers for total phosphorus.

Summary and Conclusions

This report summarizes the data collected in 1996 in the Patoka River Watershed through the use of statistical analysis. There are three primary objectives to the report. These are: determine the background level at each sampling station; classify the eight parameters of interest at each station while comparing each to the land use in the drainage area; and examine the chronic outliers found in the seasonal analysis.

Through a battery of statistical formulas, background levels were determined for the water chemistry at each sampling point. These statistics describe the population shape (distribution curve), and the central tendency of the data. These statistical values will be used when the sites are revisited to determine if change has occurred.

The stations were then classified as Low, Lower Background, Upper Background, and High for each of the parameters. The stations on the Patoka River were classified in a separate data set from tributary streams.

The data were divided into seasons and the parameter concentrations were explained through seasonal activity. Chronic outliers were stations that had outliers more than once for a given parameter. These were of interest because these stations deviated from expected seasonal levels.

From the analysis of over 800 water chemistry observations, it was concluded that:

- TOC and total phosphorus gradually increased as the water moved downstream along the Patoka River due to agricultural runoff and urban inputs.
- Strip mine drainage typically increased dissolved solids, hardness, and sulfates while reducing alkalinity for both tributary streams and the Patoka River.
- Total phosphorus and TKN had the highest concentrations in the spring due to fertilizer runoff. TOC had the highest concentration in the winter due to foliage decomposition. Dissolved Solids, hardness, and sulfate were typically highest during the summer due to high flow conditions.
- Parameters which were chronic outliers for a given station had either been classified as high or upper background for that parameter.

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Appendix A
Site Locations and Descriptions

Site	Stream	Location	Hydrologic Unit Code	County
26-01	Patoka River	CR 175 West	05120209010	Orange
26-02	Patoka River	Cuzco Road	05120209020	Dubois
26-03	Patoka River	CR 300 North	05120209020	Dubois
26-04	Hall Creek	Saint Anthony Road	05120209030	Dubois
26-05	Flat Creek	CR 230 South	05120209030	Dubois
26-06	Hunley Creek	CR 660 South	05120209040	Dubois
26-07	Hunley Creek	US 231	05120209040	Dubois
26-08	Patoka River	Old Huntingburg Road	05120209050	Dubois
54-01	Flat Creek	CR 50 North	05120209060	Dubois
54-02	Patoka River	SR 257	05120209050	Pike
54-02A	Patoka River	Ironbridge Road	05120209050	Pike
54-03	Patoka River	CR 300 West	05120209070	Pike
54-04	Keg Creek	CR 50 North	05120209070	Gibson
54-05	Patoka River	SR 65	05120209070	Gibson
54-06	Patoka River	CR 890 West	05120209070	Gibson
55-01	South Fork Patoka River	SR 61	05120209070	Pike
55-02	South Fork Patoka River	CR 300 West	05120209070	Gibson

Appendix B
Statistical Definitions

Average: $\bar{x} = \sum x_i / n$

Median: The observation where half of the observations are greater and half are lower. If the sampling group has an even number, it is the average of the two central observations.

Mode: The observation that occurs the most often.

Geometric Mean: $[\prod x_i]^{1/n}$

Variance: $S^2 = (1/n-1)\sum(x_i-\bar{x})^2$

Standard Deviation: $S= (S^2)^{½}$

Standard Error: $S/n^{(½)}$

Minimum: The observation that is the smallest.

Maximum: The observation that is the largest.

Range: The difference of the maximum and minimum.

Lower Quartile: The observation where 25% of the observations are smaller.

Upper Quartile: The observation where 75% of the observations are smaller.

Interquartile Range: The difference between the upper and lower quartile values.

Skewness: $\dfrac{n\sum(x_i-\bar{x})^3}{(n-1)(n-2)S^3}$

Standardized Skewness: $\dfrac{n^{1/2}(\text{Skewness})}{6^{1/2}}$

Kurtosis: $\dfrac{n(n+1)\sum(x_i-\bar{x})^4}{(n-1)(n-2)(n-3)S^4} - \dfrac{3(n-1)^2}{(n-2)(n-3)}$

Standardized Kurtosis: $\dfrac{n^{1/2}(\text{Kurtosis})}{24^{1/2}}$

Coefficient of Variations: $100(S/\bar{x})$

Sum: $\sum X_i$

Appendix C
Descriptive Statistics

Station 26-01, Patoka River

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	110.6667	77.22494	144.1084	664	66	160	94
Total Phosphorus (mg/l)	6	0.030333	0.013196	0.047471	0.182	0.005	0.053	0.048
Dissolved Solids (mg/l)	6	163.3333	147.5336	179.1331	980	150	190	40
Sulfate (mg/l)	6	21.16667	16.54835	25.78498	127	18	30	12
TKN (mg/l)	6	0.406667	0.086724	0.72661	2.44	0.1	0.93	0.83
TOC (mg/l)	6	2.15	1.041864	3.258136	12.9	1	3.8	2.8
Hardness (mg/l)	6	124.3333	88.21282	160.4538	746	76	180	104
Chloride (mg/l)	6	3.15	1.993238	4.306762	18.9	2	4.6	2.6

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	1015.467	31.86639	13.0094	0.323848	0.845154	0.594149	1.740777	106.7508
Total Phosphorus (mg/l)	0.000267	0.01633	0.006667	-0.25377	0.845154	0.54672	1.740777	0.024645
Dissolved Solids (mg/l)	226.6667	15.05545	6.146363	1.269815	0.845154	1.531142	1.740777	162.7812
Sulfate (mg/l)	19.36667	4.400758	1.796602	2.261776	0.845154	5.35201	1.740777	20.84681
TKN (mg/l)	0.092947	0.304872	0.124463	0.944266	0.845154	1.17818	1.740777	0.30584
TOC (mg/l)	1.115	1.055936	0.431084	0.64211	0.845154	-0.45291	1.740777	1.936671
Hardness (mg/l)	1184.667	34.41899	14.05149	0.443834	0.845154	1.31294	1.740777	120.3173
Chloride (mg/l)	1.215	1.10227	0.45	0.574572	0.845154	-1.77166	1.740777	2.995964

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	105	98	130	32
Total Phosphorus (mg/l)	0.029	0.025	0.041	0.016
Dissolved Solids (mg/l)	160	150	170	20
Sulfate (mg/l)	20	19	20	1
TKN (mg/l)	0.4	0.11	0.5	0.39
TOC (mg/l)	2	1.2	2.9	1.7
Hardness (mg/l)	120	110	140	30
Chloride (mg/l)	2.85	2.2	4.4	2.2

Station 26-02, Patoka River

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	61.16667	50.53849	71.79485	367	46	74	28
Total Phosphorus (mg/l)	6	0.028833	0.014225	0.043441	0.173	0.005	0.044	0.039
Dissolved Solids (mg/l)	6	90.66667	79.727	101.6063	544	75	100	25
Sulfate (mg/l)	6	19.16667	13.83964	24.49369	115	11	25	14
TKN (mg/l)	6	0.605	0.236964	0.973036	3.63	0.22	1	0.78
TOC (mg/l)	6	2.916667	2.664656	3.168677	17.5	2.6	3.3	0.7
Hardness (mg/l)	6	69	57.58091	80.41909	414	52	80	28
Chloride (mg/l)	6	2.833333	2.240921	3.425746	17	2.3	3.5	1.2

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	102.5667	10.12752	4.134543	-0.3493	0.845154	-0.63999	1.740777	60.43736
Total Phosphorus (mg/l)	0.000194	0.01392	0.005683	-0.9873	0.845154	0.986306	1.740777	0.023928
Dissolved Solids (mg/l)	108.6667	10.42433	4.255715	-0.78615	0.845154	-1.21338	1.740777	90.14346
Sulfate (mg/l)	25.76667	5.076088	2.072304	-0.72353	0.845154	0.006276	1.740777	18.52219
TKN (mg/l)	0.12299	0.350699	0.143172	0.002504	0.845154	-2.95087	1.740777	0.510903
TOC (mg/l)	0.057667	0.240139	0.098036	0.488638	0.845154	0.510207	1.740777	2.908535
Hardness (mg/l)	118.4	10.88118	4.442222	-0.81734	0.845154	-0.67958	1.740777	68.23178
Chloride (mg/l)	0.318667	0.564506	0.230458	0.187523	0.845154	-2.78422	1.740777	2.786737

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	62	55	68	13
Total Phosphorus (mg/l)	0.03	0.025	0.039	0.014
Dissolved Solids (mg/l)	94	81	100	19
Sulfate (mg/l)	20	16	23	7
TKN (mg/l)	0.615	0.29	0.89	0.6
TOC (mg/l)	2.9	2.8	3	0.2
Hardness (mg/l)	72	60	78	18
Chloride (mg/l)	2.75	2.3	3.4	1.1

Station 26-03, Patoka River

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	52.33333	44.35026	60.31641	314	42	62	20
Total Phosphorus (mg/l)	6	0.1125	0.015991	0.209009	0.675	0.005	0.26	0.255
Dissolved Solids (mg/l)	6	106	70.07924	141.9208	636	71	160	89
Sulfate (mg/l)	6	23.16667	15.30173	31.0316	139	13	32	19
TKN (mg/l)	6	1.138333	0.318902	1.957765	6.83	0.38	2.3	1.92
TOC (mg/l)	6	3.45	2.042425	4.857575	20.7	2.2	5.9	3.7
Hardness (mg/l)	6	69.5	50.38125	88.61875	417	41	90	49
Chloride (mg/l)	6	3.95	2.548699	5.351301	23.7	2.4	5.6	3.2

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	57.86667	7.607014	3.105551	-0.17962	0.845154	-1.50039	1.740777	51.86246
Total Phosphorus (mg/l)	0.008457	0.091962	0.037544	0.714551	0.845154	-0.03875	1.740777	0.067451
Dissolved Solids (mg/l)	1171.6	34.22864	13.97378	0.587817	0.845154	-0.41326	1.740777	101.5296
Sulfate (mg/l)	56.16667	7.494442	3.059593	-0.01386	0.845154	-1.55674	1.740777	22.09617
TKN (mg/l)	0.609697	0.780831	0.318773	0.819089	0.845154	-1.29725	1.740777	0.930335
TOC (mg/l)	1.799	1.341268	0.54757	1.507248	0.845154	2.221403	1.740777	3.266568
Hardness (mg/l)	331.9	18.21812	7.437518	-0.56933	0.845154	-0.35055	1.740777	67.26393
Chloride (mg/l)	1.783	1.33529	0.54513	0.229459	0.845154	-1.8328	1.740777	3.759123

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	53.5	46	57	11
Total Phosphorus (mg/l)	0.0935	0.053	0.17	0.117
Dissolved Solids (mg/l)	106.5	72	120	48
Sulfate (mg/l)	22	19	31	12
TKN (mg/l)	0.835	0.58	1.9	1.32
TOC (mg/l)	3	2.6	4	1.4
Hardness (mg/l)	71	58	86	28
Chloride (mg/l)	3.8	2.7	5.4	2.7

	Valid N	Mean	-95.000%	Confid. 95.000	Sum	Minimum	Maximum	Rang
Alkalinity (mg/l)	6	54.5	30.00742	78.99258	327	35	94	59
Total Phosphorus (mg/l)	6	0.117167	0.036502	0.197831	0.703	0.04	0.24	0.2
Dissolved Solids (mg/l)	6	155	133.2384	176.7616	930	130	180	50
Sulfate (mg/l)	6	45.83333	25.58802	66.07865	275	32	84	52
TKN (mg/l)	6	1.021667	0.354093	1.68924	6.13	0.06	1.8	1.74
TOC (mg/l)	6	3.15	1.955763	4.344237	18.9	1.9	5.3	3.4
Hardness (mg/l)	6	96.16667	81.84786	110.4855	577	75	110	35
Chloride (mg/l)	6	10.21667	7.240695	13.19264	61.3	7	15	8

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	544.7	23.33881	9.528029	1.260516	0.845154	0.246413	1.740777	50.95831
Total Phosphorus (mg/l)	0.005908	0.076865	0.03138	0.947817	0.845154	-0.46374	1.740777	0.097819
Dissolved Solids (mg/l)	430	20.73644	8.465617	-0.40374	0.845154	-1.61709	1.740777	153.8065
Sulfate (mg/l)	372.1667	19.29162	7.875772	2.130985	0.845154	4.753638	1.740777	43.28623
TKN (mg/l)	0.404657	0.636126	0.259697	-0.41129	0.845154	-0.67028	1.740777	0.693713
TOC (mg/l)	1.295	1.137981	0.464579	1.603124	0.845154	3.706939	1.740777	3.0029
Hardness (mg/l)	186.1667	13.64429	5.570258	-0.57924	0.845154	-0.56959	1.740777	95.31946
Chloride (mg/l)	8.041667	2.835783	1.157704	0.861156	0.845154	0.85267	1.740777	9.906599

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	43	40	72	32
Total Phosphorus (mg/l)	0.089	0.065	0.18	0.115
Dissolved Solids (mg/l)	160	130	170	40
Sulfate (mg/l)	39	35	46	11
TKN (mg/l)	1.07	0.63	1.5	0.87
TOC (mg/l)	2.95	2.7	3.1	0.4
Hardness (mg/l)	97.5	87	110	23
Chloride (mg/l)	10.15	8	11	3

Station 26-05, Flat Creek

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	44.83333	25.59209	64.07458	269	28	70	42
Total Phosphorus (mg/l)	6	0.099	0.053565	0.144435	0.594	0.05	0.16	0.11
Dissolved Solids (mg/l)	6	161.6667	127.5533	195.7801	970	130	210	80
Sulfate (mg/l)	6	47.33333	34.33275	60.33392	284	36	70	34
TKN (mg/l)	6	0.881667	0.456449	1.306885	5.29	0.33	1.4	1.07
TOC (mg/l)	6	2.983333	2.074697	3.891969	17.9	2	4.2	2.2
Hardness (mg/l)	6	98.5	75.51041	121.4896	591	73	130	57
Chloride (mg/l)	6	10.51667	7.045958	13.98738	63.1	6.6	15	8.4

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	336.1667	18.33485	7.485171	0.830823	0.845154	-1.76397	1.740777	52.31709
Total Phosphorus (mg/l)	0.001874	0.043294	0.017675	0.451958	0.845154	-1.36225	1.740777	0.196124
Dissolved Solids (mg/l)	1056.667	32.50641	13.27069	0.616234	0.845154	-1.15207	1.740777	258.7673
Sulfate (mg/l)	153.4667	12.38817	5.057448	1.506721	0.845154	2.268199	1.740777	69.03919
TKN (mg/l)	0.164177	0.405187	0.165417	-0.18984	0.845154	-1.25382	1.740777	1.195069
TOC (mg/l)	0.749667	0.865833	0.353475	0.66021	0.845154	-1.37381	1.740777	4.068187
Hardness (mg/l)	479.9	21.90662	8.94334	0.242186	0.845154	-1.31332	1.740777	127.6004
Chloride (mg/l)	10.93767	3.307214	1.350165	0.175875	0.845154	-1.83907	1.740777	23.60091

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	47.5	42	75	33
Total Phosphorus (mg/l)	0.195	0.16	0.24	0.08
Dissolved Solids (mg/l)	265	240	270	30
Sulfate (mg/l)	64.5	60	68	8
TKN (mg/l)	1.3	0.85	2	1.15
TOC (mg/l)	4	3.2	5.3	2.1
Hardness (mg/l)	135	110	140	30
Chloride (mg/l)	24	18	33	15

Station 26-06, Hunley Creek

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	54.33333	36.68949	71.97717	326	38	76	38
Total Phosphorus (mg/l)	6	0.2	0.154498	0.245502	1.2	0.15	0.26	0.11
Dissolved Solids (mg/l)	6	260	231.0691	288.9309	1560	220	300	80
Sulfate (mg/l)	6	70.83333	50.35006	91.3166	425	58	110	52
TKN (mg/l)	6	1.326667	0.693111	1.960222	7.96	0.51	2	1.49
TOC (mg/l)	6	4.183333	3.046418	5.320249	25.1	3	5.6	2.6
Hardness (mg/l)	6	128.3333	112.8861	143.7806	770	110	140	30
Chloride (mg/l)	6	24.66667	16.41229	32.92104	148	16	33	17

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	282.6667	16.81269	6.863753	0.759688	0.845154	-1.84553	1.740777	52.31709
Total Phosphorus (mg/l)	0.00188	0.043359	0.017701	0.331228	0.845154	-1.42938	1.740777	0.196124
Dissolved Solids (mg/l)	760	27.5681	11.25463	-0.08591	0.845154	0.17313	1.740777	258.7673
Sulfate (mg/l)	380.9667	19.51837	7.96834	2.265678	0.845154	5.313526	1.740777	69.03919
TKN (mg/l)	0.364467	0.603711	0.246464	-0.06008	0.845154	-1.46605	1.740777	1.195069
TOC (mg/l)	1.173667	1.083359	0.442279	0.357792	0.845154	-1.91368	1.740777	4.068187
Hardness (mg/l)	216.6667	14.7196	6.009252	-0.71072	0.845154	-2.05207	1.740777	127.6004
Chloride (mg/l)	61.86667	7.865537	3.211092	0.067541	0.845154	-2.83992	1.740777	23.60091

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	47.5	42	75	33
Total Phosphorus (mg/l)	0.195	0.16	0.24	0.08
Dissolved Solids (mg/l)	265	240	270	30
Sulfate (mg/l)	64.5	60	68	8
TKN (mg/l)	1.3	0.85	2	1.15
TOC (mg/l)	4	3.2	5.3	2.1
Hardness (mg/l)	135	110	140	30
Chloride (mg/l)	24	18	33	15

Station 26-07, Hunley Creek

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	60	40.49066	79.50934	360	42	84	42
Total Phosphorus (mg/l)	6	0.228333	0.109897	0.346769	1.37	0.09	0.39	0.3
Dissolved Solids (mg/l)	6	215	177.0168	252.9832	1290	160	260	100
Sulfate (mg/l)	6	51.66667	29.32905	74.00428	310	37	94	57
TKN (mg/l)	6	2.251667	1.505447	2.997886	13.51	0.91	2.9	1.99
TOC (mg/l)	6	6.5	4.852687	8.147313	39	3.8	8.3	4.5
Hardness (mg/l)	6	108.3333	82.18013	134.4865	650	79	140	61
Chloride (mg/l)	6	19	10.02134	27.97866	114	11	31	20

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	345.6	18.59032	7.589466	0.661186	0.845154	-1.97065	1.740777	57.73798
Total Phosphorus (mg/l)	0.012737	0.112857	0.046074	0.027433	0.845154	-0.83243	1.740777	0.2016
Dissolved Solids (mg/l)	1310	36.19392	14.77611	-0.45556	0.845154	-0.50522	1.740777	212.3249
Sulfate (mg/l)	453.0667	21.28536	8.689713	2.170235	0.845154	4.986991	1.740777	48.91793
TKN (mg/l)	0.505617	0.711067	0.290292	-1.70004	0.845154	3.229846	1.740777	2.116065
TOC (mg/l)	2.464	1.569713	0.640833	-0.94799	0.845154	1.334904	1.740777	6.314885
Hardness (mg/l)	621.0667	24.92121	10.17404	0.133827	0.845154	-2.27916	1.740777	105.932
Chloride (mg/l)	73.2	8.5557	3.49285	0.411	0.845154	-1.97729	1.740777	17.41464

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	53	46	82	36
Total Phosphorus (mg/l)	0.25	0.11	0.28	0.17
Dissolved Solids (mg/l)	220	190	240	50
Sulfate (mg/l)	46.5	38	48	10
TKN (mg/l)	2.45	2.1	2.7	0.6
TOC (mg/l)	6.6	6	7.7	1.7
Hardness (mg/l)	105.5	90	130	40
Chloride (mg/l)	17.5	11	26	15

Station 26-08, Patoka River

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	50.16667	38.10196	62.23137	301	37	64	27
Total Phosphorus (mg/l)	6	0.253333	0.091888	0.414778	1.52	0.06	0.47	0.41
Dissolved Solids (mg/l)	6	139.3333	101.3985	177.2682	836	96	180	84
Sulfate (mg/l)	6	29	16.47693	41.52307	174	12	45	33
TKN (mg/l)	6	1.416667	0.491789	2.341544	8.5	0.34	2.5	2.16
TOC (mg/l)	6	4.6	2.480244	6.719756	27.6	2.6	7.6	5
Hardness (mg/l)	6	77.33333	62.63124	92.03542	464	62	100	38
Chloride (mg/l)	6	7.416667	3.9881	10.84523	44.5	4.3	12	7.7

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	132.1667	11.49638	4.693376	-0.07097	0.845154	-2.26694	1.740777	49.03924
Total Phosphorus (mg/l)	0.023667	0.15384	0.062805	0.125611	0.845154	-1.23102	1.740777	0.205783
Dissolved Solids (mg/l)	1306.667	36.14784	14.7573	-0.24209	0.845154	-2.26124	1.740777	135.2102
Sulfate (mg/l)	142.4	11.93315	4.871687	0.047667	0.845154	-0.55148	1.740777	26.69227
TKN (mg/l)	0.776707	0.88131	0.359793	0.291146	0.845154	-1.81351	1.740777	1.154544
TOC (mg/l)	4.08	2.019901	0.824621	0.567879	0.845154	-1.36574	1.740777	4.242589
Hardness (mg/l)	196.2667	14.00952	5.719363	0.566749	0.845154	0.324914	1.740777	76.30134
Chloride (mg/l)	10.67367	3.267058	1.333771	0.786011	0.845154	-1.66659	1.740777	6.867374

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	51	38	60	22
Total Phosphorus (mg/l)	0.265	0.12	0.34	0.22
Dissolved Solids (mg/l)	145	100	170	70
Sulfate (mg/l)	27	23	40	17
TKN (mg/l)	1.2	0.86	2.4	1.54
TOC (mg/l)	4.2	2.8	6.2	3.4
Hardness (mg/l)	79	63	81	18
Chloride (mg/l)	6.1	5	11	6

Station 54-01, Flat Creek

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	98.33333	49.91502	146.7516	590	44	160	116
Total Phosphorus (mg/l)	6	0.219667	0.007918	0.431415	1.318	0.078	0.62	0.542
Dissolved Solids (mg/l)	6	530	269.4524	790.5476	3180	230	880	650
Sulfate (mg/l)	6	239	117.166	360.834	1434	100	404	304
TKN (mg/l)	6	1.488333	0.88876	2.087906	8.93	0.95	2.2	1.25
TOC (mg/l)	6	6.066667	3.554443	8.578891	36.4	4.2	10.3	6.1
Hardness (mg/l)	6	331.6667	164.3593	498.974	1990	130	540	410
Chloride (mg/l)	6	13.3	8.326516	18.27348	79.8	5.8	20	14.2

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	2128.667	46.13748	18.83555	0.143459	0.845154	-1.49208	1.740777	88.55238
Total Phosphorus (mg/l)	0.040713	0.201774	0.082374	2.153722	0.845154	4.870657	1.740777	0.17014
Dissolved Solids (mg/l)	61640	248.274	101.3575	0.03458	0.845154	-1.06821	1.740777	475.6292
Sulfate (mg/l)	13478	116.0948	47.3955	0.125412	0.845154	-1.01667	1.740777	212.8845
TKN (mg/l)	0.326417	0.571329	0.233244	0.675875	0.845154	-1.87255	1.740777	1.402642
TOC (mg/l)	5.730667	2.393881	0.977298	1.41434	0.845154	1.198299	1.740777	5.734903
Hardness (mg/l)	25416.67	159.4261	65.08541	-0.21355	0.845154	-1.32376	1.740777	293.5598
Chloride (mg/l)	22.46	4.739198	1.93477	-0.34802	0.845154	0.998881	1.740777	12.45459

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	97	52	140	88
Total Phosphorus (mg/l)	0.155	0.11	0.2	0.09
Dissolved Solids (mg/l)	565	270	670	400
Sulfate (mg/l)	245	120	320	200
TKN (mg/l)	1.3	0.98	2.2	1.22
TOC (mg/l)	5.05	4.3	7.5	3.2
Hardness (mg/l)	360	160	440	280
Chloride (mg/l)	14	11	15	4

Station 54-02, Patoka River

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	53.83333	39.80985	67.85682	323	38	68	30
Total Phosphorus (mg/l)	6	0.235	0.097568	0.372432	1.41	0.07	0.42	0.35
Dissolved Solids (mg/l)	6	156.6667	121.1302	192.2031	940	100	200	100
Sulfate (mg/l)	6	39.16667	26.68912	51.64422	235	19	55	36
TKN (mg/l)	6	1.415	0.479512	2.350488	8.49	0.5	3	2.5
TOC (mg/l)	6	5	2.75411	7.24589	30	2.6	7.8	5.2
Hardness (mg/l)	6	81.5	60.18069	102.8193	489	61	120	59
Chloride (mg/l)	6	7.6	4.486871	10.71313	45.6	4.9	13	8.1

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	178.5667	13.36288	5.455375	-0.05489	0.845154	-2.71551	1.740777	52.41566
Total Phosphorus (mg/l)	0.01715	0.130958	0.053463	0.2212	0.845154	-1.25826	1.740777	0.200339
Dissolved Solids (mg/l)	1146.667	33.86247	13.82429	-0.77605	0.845154	1.191522	1.740777	153.2366
Sulfate (mg/l)	141.3667	11.88977	4.853979	-0.744	0.845154	1.776812	1.740777	37.32425
TKN (mg/l)	0.79463	0.89142	0.363921	1.238678	0.845154	1.714439	1.740777	1.204131
TOC (mg/l)	4.58	2.140093	0.873689	0.115695	0.845154	-2.09722	1.740777	4.598597
Hardness (mg/l)	412.7	20.31502	8.293572	1.682024	0.845154	3.562993	1.740777	79.66288
Chloride (mg/l)	8.8	2.966479	1.21106	1.484197	0.845154	2.099384	1.740777	7.191964

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	54	42	67	25
Total Phosphorus (mg/l)	0.225	0.14	0.33	0.19
Dissolved Solids (mg/l)	165	140	170	30
Sulfate (mg/l)	41	35	44	9
TKN (mg/l)	1.29	0.81	1.6	0.79
TOC (mg/l)	5	2.9	6.7	3.8
Hardness (mg/l)	77	71	83	12
Chloride (mg/l)	6.6	5.7	8.8	3.1

Station 54-02A, Patoka River

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	2	55	-110.181	220.1807	110	42	68	26
Total Phosphorus (mg/l)	2	0.255	-1.5874	2.0974	0.51	0.11	0.4	0.29
Dissolved Solids (mg/l)	2	133.5	-330.276	597.2765	267	97	170	73
Sulfate (mg/l)	2	35	-130.181	200.1807	70	22	48	26
TKN (mg/l)	2	1.25	-4.46779	6.967792	2.5	0.8	1.7	0.9
TOC (mg/l)	2	5.7	-27.3361	38.73613	11.4	3.1	8.3	5.2
Hardness (mg/l)	2	82			164	82	82	0
Chloride (mg/l)	2	6.5	-20.183	33.18303	13	4.4	8.6	4.2

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	338	18.38478	13					53.44156
Total Phosphorus (mg/l)	0.04205	0.205061	0.145					0.209762
Dissolved Solids (mg/l)	2664.5	51.6188	36.5					128.4134
Sulfate (mg/l)	338	18.38478	13					32.49615
TKN (mg/l)	0.405	0.636396	0.45					1.16619
TOC (mg/l)	13.52	3.676955	2.6					5.072475
Hardness (mg/l)	0	0	0					82
Chloride (mg/l)	8.82	2.969848	2.1					6.151423

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	55	42	68	26
Total Phosphorus (mg/l)	0.255	0.11	0.4	0.29
Dissolved Solids (mg/l)	133.5	97	170	73
Sulfate (mg/l)	35	22	48	26
TKN (mg/l)	1.25	0.8	1.7	0.9
TOC (mg/l)	5.7	3.1	8.3	5.2
Hardness (mg/l)	82	82	82	0
Chloride (mg/l)	6.5	4.4	8.6	4.2

Station 54-03, Patoka River

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	52.33333	38.83404	65.83263	314	38	68	30
Total Phosphorus (mg/l)	6	0.201167	0.037629	0.364704	1.207	0.077	0.5	0.423
Dissolved Solids (mg/l)	6	236.6667	167.1605	306.1728	1420	170	350	180
Sulfate (mg/l)	6	94.16667	30.77375	157.5596	565	53	210	157
TKN (mg/l)	6	1.278333	0.807212	1.749455	7.67	0.89	1.9	1.01
TOC (mg/l)	6	4.108333	1.28256	6.934106	24.65	0.05	7.9	7.85
Hardness (mg/l)	6	137.8333	77.88339	197.7833	827	98	240	142
Chloride (mg/l)	6	7.366667	4.080296	10.65304	44.2	4.8	13	8.2

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	165.4667	12.86338	5.251455	0.256586	0.845154	-2.31933	1.740777	51.02556
Total Phosphorus (mg/l)	0.024284	0.155834	0.063619	1.818026	0.845154	3.756269	1.740777	0.162909
Dissolved Solids (mg/l)	4386.667	66.23192	27.03907	1.042436	0.845154	0.892938	1.740777	229.5535
Sulfate (mg/l)	3648.967	60.40668	24.66092	1.893934	0.845154	3.548099	1.740777	82.47356
TKN (mg/l)	0.201537	0.448928	0.183274	0.894843	0.845154	-1.75029	1.740777	1.219006
TOC (mg/l)	7.250417	2.69266	1.099274	-0.09016	0.845154	0.344422	1.740777	2.16963
Hardness (mg/l)	3263.367	57.12588	23.32154	1.477467	0.845154	1.438137	1.740777	129.6534
Chloride (mg/l)	9.806667	3.13156	1.278454	1.395443	0.845154	1.733035	1.740777	6.895808

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	50	42	66	24
Total Phosphorus (mg/l)	0.17	0.08	0.21	0.13
Dissolved Solids (mg/l)	225	180	270	90
Sulfate (mg/l)	69	54	110	56
TKN (mg/l)	1.05	0.98	1.8	0.82
TOC (mg/l)	3.8	3	6.1	3.1
Hardness (mg/l)	110	99	170	71
Chloride (mg/l)	6.4	5.1	8.5	3.4

Station 54-04, Keg Creek

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	81	35.61873	126.3813	486	48	150	102
Total Phosphorus (mg/l)	6	0.288333	0.138089	0.438577	1.73	0.19	0.57	0.38
Dissolved Solids (mg/l)	6	380	105.6975	654.3025	2280	150	850	700
Sulfate (mg/l)	6	143.3333	-14.0116	300.6782	860	34	420	386
TKN (mg/l)	6	2.1	1.017503	3.182497	12.6	1.2	4	2.8
TOC (mg/l)	6	6.45	2.791245	10.10875	38.7	2	11.9	9.9
Hardness (mg/l)	6	255.8333	-9.20717	520.8738	1535	95	740	645
Chloride (mg/l)	6	15	10.85506	19.14494	90	11	21	10

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	1870	43.2435	17.65408	1.101565	0.845154	-0.69256	1.740777	72.82197
Total Phosphorus (mg/l)	0.020497	0.143167	0.058448	2.069164	0.845154	4.5686	1.740777	0.266444
Dissolved Solids (mg/l)	68320	261.3809	106.7083	1.447758	0.845154	1.716063	1.740777	318.9818
Sulfate (mg/l)	22479.87	149.9329	61.20984	1.641675	0.845154	2.314321	1.740777	94.25644
TKN (mg/l)	1.064	1.031504	0.42111	1.525257	0.845154	2.443362	1.740777	1.925759
TOC (mg/l)	12.155	3.486402	1.423318	0.526273	0.845154	-3.4E-05	1.740777	5.593646
Hardness (mg/l)	63784.17	252.5553	103.1053	1.91041	0.845154	3.49249	1.740777	187.0805
Chloride (mg/l)	15.6	3.949684	1.612452	0.555059	0.845154	-0.81361	1.740777	14.57973

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	60	48	120	72
Total Phosphorus (mg/l)	0.25	0.19	0.28	0.09
Dissolved Solids (mg/l)	285	200	510	310
Sulfate (mg/l)	79.5	37	210	173
TKN (mg/l)	1.85	1.4	2.3	0.9
TOC (mg/l)	5.75	4.6	8.7	4.1
Hardness (mg/l)	130	110	330	220
Chloride (mg/l)	14.5	11	18	7

Station 54-05, Patoka River

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	53.16667	27.18457	79.14877	319	16	87	71
Total Phosphorus (mg/l)	6	0.268333	0.111631	0.425036	1.61	0.17	0.56	0.39
Dissolved Solids (mg/l)	6	331.6667	227.9016	435.4317	1990	220	500	280
Sulfate (mg/l)	6	165	99.71532	230.2847	990	90	250	160
TKN (mg/l)	6	1.433333	0.979925	1.886741	8.6	1	2.2	1.2
TOC (mg/l)	6	4.275	1.683563	6.866437	25.65	0.05	6.6	6.55
Hardness (mg/l)	6	211.6667	126.0449	297.2884	1270	120	340	220
Chloride (mg/l)	6	9.1	3.626411	14.57359	54.6	4.8	19	14.2

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	612.9667	24.75816	10.10748	-0.19146	0.845154	-0.05803	1.740777	47.0181
Total Phosphorus (mg/l)	0.022297	0.149321	0.06096	2.03539	0.845154	4.21818	1.740777	0.243359
Dissolved Solids (mg/l)	9776.667	98.87703	40.36638	0.965324	0.845154	1.003876	1.740777	320.2164
Sulfate (mg/l)	3870	62.20932	25.39685	0.284112	0.845154	-1.63952	1.740777	155.0602
TKN (mg/l)	0.186667	0.432049	0.176383	1.244071	0.845154	1.66875	1.740777	1.384632
TOC (mg/l)	6.09775	2.469362	1.008113	-1.03646	0.845154	0.80636	1.740777	2.29343
Hardness (mg/l)	6656.667	81.5884	33.30832	0.564837	0.845154	-0.37278	1.740777	198.7782
Chloride (mg/l)	27.204	5.215745	2.129319	1.756498	0.845154	3.35005	1.740777	8.133256

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	52	42	70	28
Total Phosphorus (mg/l)	0.205	0.18	0.29	0.11
Dissolved Solids (mg/l)	315	260	380	120
Sulfate (mg/l)	155	120	220	100
TKN (mg/l)	1.35	1.1	1.6	0.5
TOC (mg/l)	4.65	3.2	6.5	3.3
Hardness (mg/l)	210	140	250	110
Chloride (mg/l)	7.7	5.5	9.9	4.4

Station 54-06, Patoka River

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	62.5	40.83227	84.16773	375	35	82	47
Total Phosphorus (mg/l)	6	0.17	0.124984	0.215016	1.02	0.12	0.23	0.11
Dissolved Solids (mg/l)	6	343.6667	234.9669	452.3665	2062	210	520	310
Sulfate (mg/l)	6	149	86.61372	211.3863	894	74	230	156
TKN (mg/l)	6	1.203333	0.880512	1.526155	7.22	0.86	1.6	0.74
TOC (mg/l)	6	3.858333	1.317395	6.399272	23.15	0.05	7.3	7.25
Hardness (mg/l)	6	203.3333	124.3347	282.332	1220	120	320	200
Chloride (mg/l)	6	9.883333	3.582028	16.18464	59.3	4.7	21	16.3

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	426.3	20.64703	8.429116	-0.28334	0.845154	-2.43531	1.740777	58.19779
Total Phosphorus (mg/l)	0.00184	0.042895	0.017512	0.27367	0.845154	-1.74267	1.740777	0.110546
Dissolved Solids (mg/l)	10728.67	103.5793	42.28606	0.803892	0.845154	1.633265	1.740777	256.2809
Sulfate (mg/l)	3534	59.44746	24.26932	0.409887	0.845154	-1.20818	1.740777	78.82192
TKN (mg/l)	0.094627	0.307614	0.125583	0.26941	0.845154	-2.20824	1.740777	1.010545
TOC (mg/l)	5.862417	2.421243	0.988468	-0.27345	0.845154	0.975857	1.740777	3.107869
Hardness (mg/l)	5666.667	75.27727	30.73181	0.502456	0.845154	-0.42556	1.740777	152.0804
Chloride (mg/l)	36.05367	6.004471	2.451315	1.542317	0.845154	2.663122	1.740777	8.565389

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	57	44	75	31
Total Phosphorus (mg/l)	0.14	0.055	0.23	0.175
Dissolved Solids (mg/l)	205	150	322	172
Sulfate (mg/l)	53.5	32	140	108
TKN (mg/l)	1.05	0.78	1.6	0.82
TOC (mg/l)	3.6	2.7	5.3	2.6
Hardness (mg/l)	120	82	190	108
Chloride (mg/l)	8.9	5.1	14	8.9

Station 55-01, South Fork Patoka River

	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	57.5	19.18913	95.81087	345	23	110	87
Total Phosphorus (mg/l)	6	0.040833	0.010516	0.07115	0.245	0.01	0.091	0.081
Dissolved Solids (mg/l)	6	2190	1053.601	3326.399	13140	640	3500	2860
Sulfate (mg/l)	6	1566.667	1170.282	1963.052	9400	1000	2000	1000
TKN (mg/l)	6	0.855	0.492086	1.217914	5.13	0.41	1.4	0.99
TOC (mg/l)	6	1.991667	0.970734	3.012599	11.95	0.05	2.6	2.55
Hardness (mg/l)	5	1440	803.2309	2076.769	7200	1000	2300	1300
Chloride (mg/l)	6	16.98333	2.796079	31.17059	101.9	7.9	44	36.1

	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	1332.7	36.50616	14.90358	0.802312	0.845154	-1.50693	1.740777	48.59324
Total Phosphorus (mg/l)	0.000835	0.028889	0.011794	1.14277	0.845154	1.190743	1.740777	0.032688
Dissolved Solids (mg/l)	1172600	1082.867	442.0784	-0.10479	0.845154	-0.92332	1.740777	1911.544
Sulfate (mg/l)	142666.7	377.7124	154.2004	-0.44785	0.845154	-0.88108	1.740777	1525.379
TKN (mg/l)	0.11959	0.345818	0.14118	0.600611	0.845154	0.202149	1.740777	0.796382
TOC (mg/l)	0.946417	0.972839	0.39716	-2.21293	0.845154	5.095264	1.740777	1.246316
Hardness (mg/l)	263000	512.8353	229.3469	1.579974	0.912871	2.804291	2	1377.448
Chloride (mg/l)	182.7617	13.51894	5.519083	2.222382	0.845154	5.157598	1.740777	14.10762

	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	44	28	96	68
Total Phosphorus (mg/l)	0.032	0.025	0.055	0.03
Dissolved Solids (mg/l)	2100	1500	3300	1800
Sulfate (mg/l)	1600	1300	1900	600
TKN (mg/l)	0.76	0.7	1.1	0.4
TOC (mg/l)	2.3	2.1	2.6	0.5
Hardness (mg/l)	1400	1100	1400	300
Chloride (mg/l)	13	9	15	6

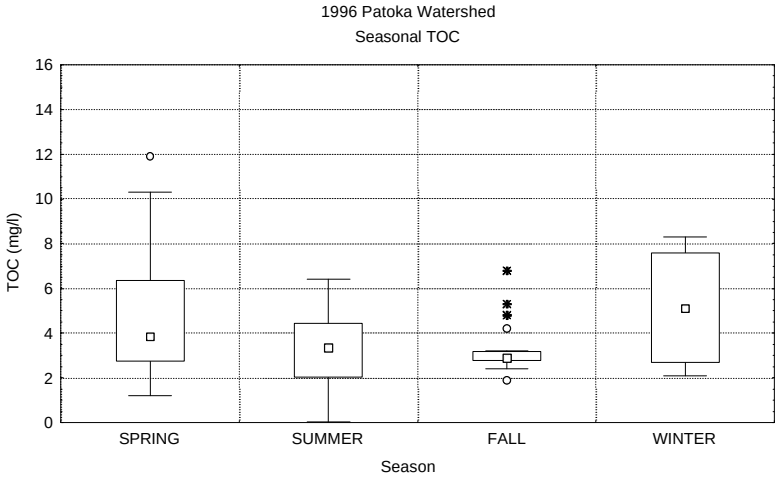
Station 55-02, South Fork Patoka River

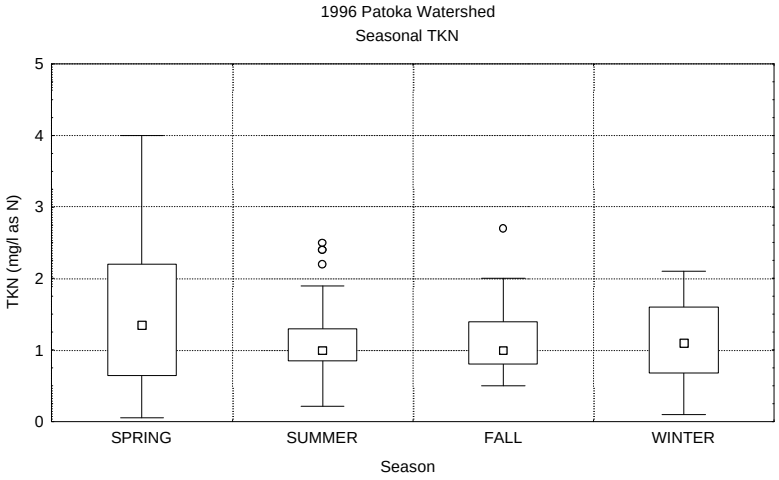
	Valid N	Mean	Confid. -95.000%	Confid. 95.000	Sum	Minimum	Maximum	Range
Alkalinity (mg/l)	6	87.16667	30.01561	144.3177	523	22	170	148
Total Phosphorus (mg/l)	6	0.1035	-0.01382	0.220817	0.621	0.037	0.32	0.283
Dissolved Solids (mg/l)	6	1705	672.4119	2737.588	10230	730	3000	2270
Sulfate (mg/l)	6	1076.667	471.3445	1681.989	6460	480	1800	1320
TKN (mg/l)	6	1.166667	0.257037	2.076296	7	0.34	2.8	2.46
TOC (mg/l)	6	3.508333	1.32147	5.695196	21.05	0.05	6.5	6.45
Hardness (mg/l)	6	1073.333	394.6911	1751.976	6440	500	1900	1400
Chloride (mg/l)	6	13.78333	4.267222	23.29944	82.7	5.7	31	25.3

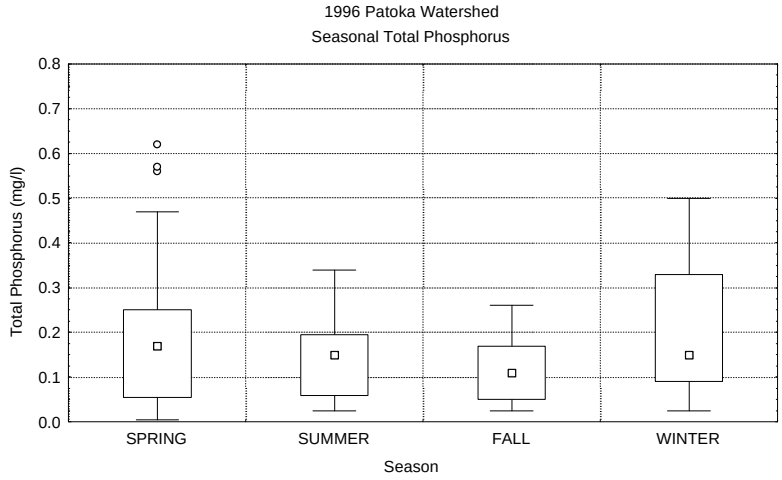
	Variance	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis	geometrc mean
Alkalinity (mg/l)	2965.767	54.45885	22.23273	0.579706	0.845154	-0.65741	1.740777	71.75432
Total Phosphorus (mg/l)	0.012497	0.11179	0.045638	1.984901	0.845154	3.857443	1.740777	0.071516
Dissolved Solids (mg/l)	968150	983.9461	401.6943	0.798245	0.845154	-1.7831	1.740777	1488.995
Sulfate (mg/l)	332706.7	576.8073	235.4806	0.718201	0.845154	-1.80381	1.740777	956.1739
TKN (mg/l)	0.751307	0.866779	0.353861	1.670243	0.845154	3.248269	1.740777	0.947649
TOC (mg/l)	4.342417	2.083847	0.850727	-0.47533	0.845154	2.041554	1.740777	1.947304
Hardness (mg/l)	418186.7	646.6735	264.0034	0.881312	0.845154	-1.85765	1.740777	930.9613
Chloride (mg/l)	82.22567	9.067837	3.701929	1.773176	0.845154	3.367275	1.740777	11.87658

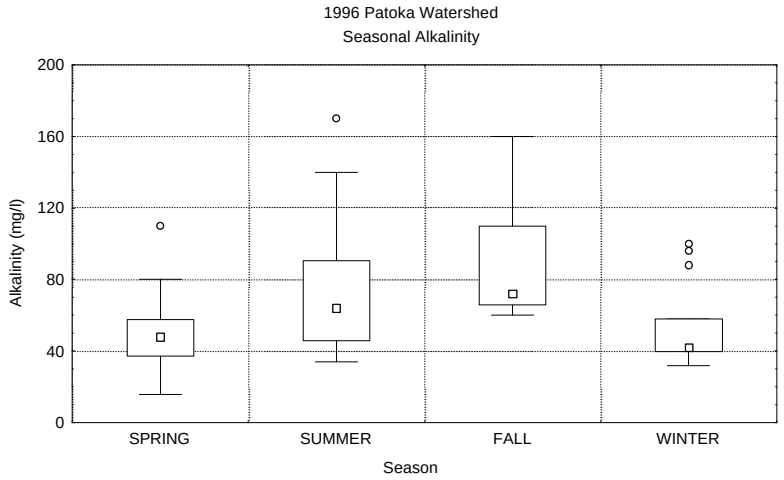
	median	25.000th percentl	75.000th percentl	quartile range
Alkalinity (mg/l)	73	55	130	75
Total Phosphorus (mg/l)	0.047	0.04	0.13	0.09
Dissolved Solids (mg/l)	1250	1100	2900	1800
Sulfate (mg/l)	840	700	1800	1100
TKN (mg/l)	0.93	0.7	1.3	0.6
TOC (mg/l)	3.65	3.1	4.1	1
Hardness (mg/l)	730	680	1900	1220
Chloride (mg/l)	10.3	9.4	16	6.6

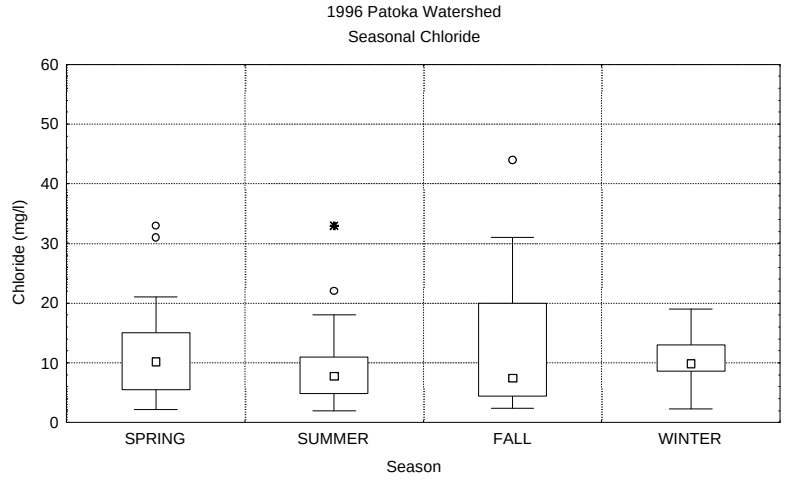
APPENDIX D
SEASONAL BOX-WHISKER PLOTS

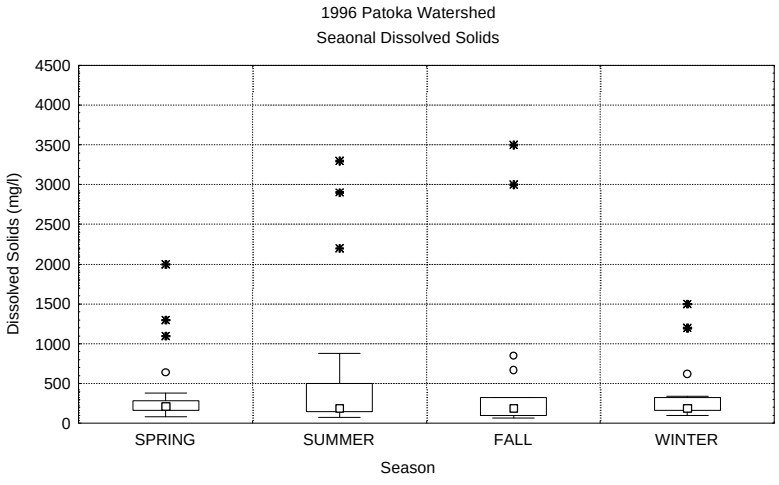


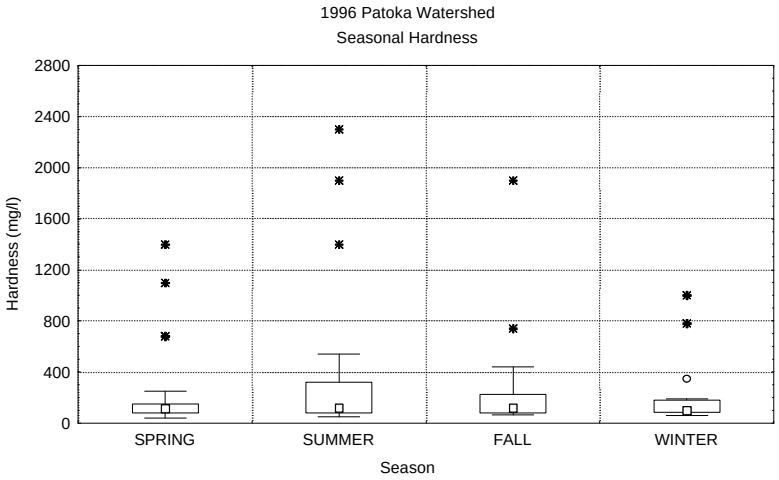


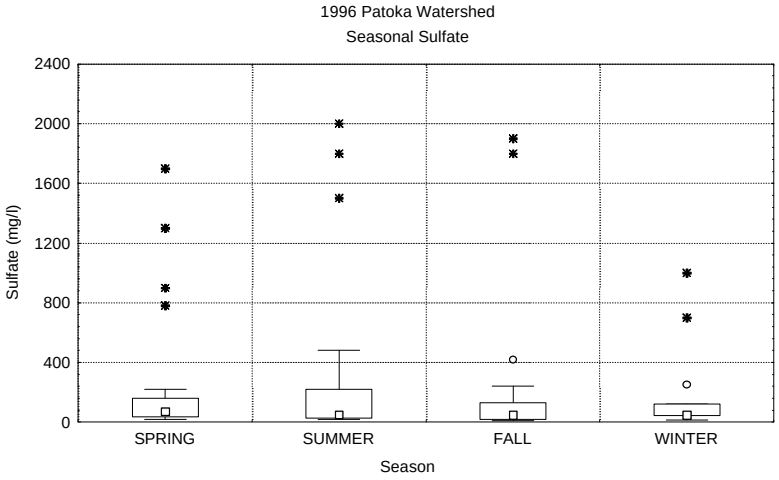



1996 Patoka Watershed
Seasonal Alkalinity
Alkalinity (mg/l)
200
160
120
80
40
0
SPRING
SUMMER
FALL
WINTER
Season


1996 Patoka Watershed
Seasonal Chloride
Chloride (mg/l)
60
50
40
30
20
10
0
SPRING
SUMMER
FALL
WINTER
Season

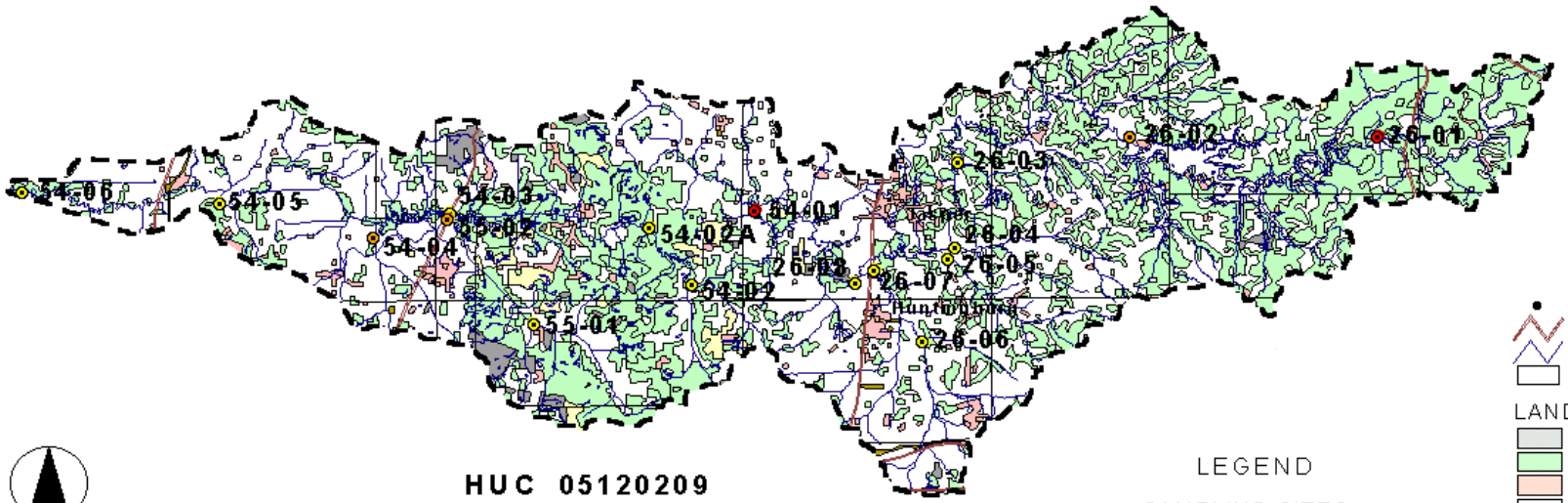

1996 Patoka Watershed
Seaonal Dissolved Solids
Dissolved Solids (mg/l)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
SPRING
SUMMER
FALL
WINTER
Season


1996 Patoka Watershed
Seasonal Hardness
Hardness (mg/l)
2800
2400
2000
1600
1200
800
400
0
SPRING
SUMMER
FALL
WINTER
Season


1996 Patoka Watershed
Seasonal Sulfate
Sulfate (mg/l)
2400
2000
1600
1200
800
400
0
SPRING
SUMMER
FALL
WINTER
Season

Patoka River Watershed

Alkalinity (mg/l)



HUC 05120209

1:375000

5 0 5 10 15 Miles

LEGEND

SAMPLING SITES:
- High
- Low
- Upper Background
- Lower Background

Cities and Towns
Major Roads
Rivers and Streams
County Boundaries

LAND USE:
- Agricultural Land
- Forest Land
- Commercial and Urban
- Industrial Land
- Residential Land
- Transitional Areas
- Strip Mine Land
- Communication/Utilities/ Transportation

Map Reference

Projection: UTM, Zone 16
Printed: April 1998
Plate Preparation: Joanna Wood

IDEM/Office of Water Management
Assessment Branch/Survey Section

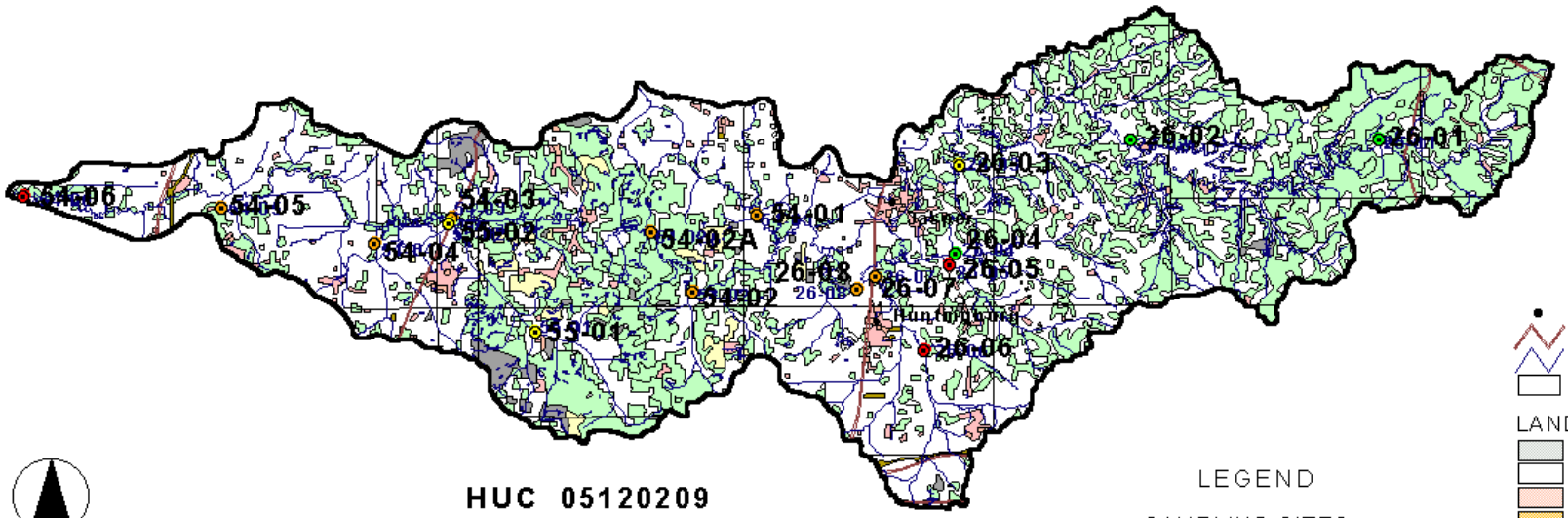
IDEM

PLATE 1 - Patoka River Watershed, Alkalinity

Indiana Department of Environmental Management (1998). *Patoka River Basin 1996 Statistical Analysis*, by Carl Christensen, MSES. Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Survey Section, Indianapolis, Indiana. IDEM 32/02/000/1998.

Patoka River Watershed

Chloride (mg/l)



HUC 05120209

1:375000

5 0 5 10 15 Miles

LEGEND

SAMPLING SITES:
- High
- Low
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- Lower Background

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- Major Roads
- Rivers and Streams
- County Boundaries

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Map Reference

Projection: UTM, Zone 16
Printed: April 1998
Plate Preparation: Joanna Wood

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Assessment Branch/Survey Section

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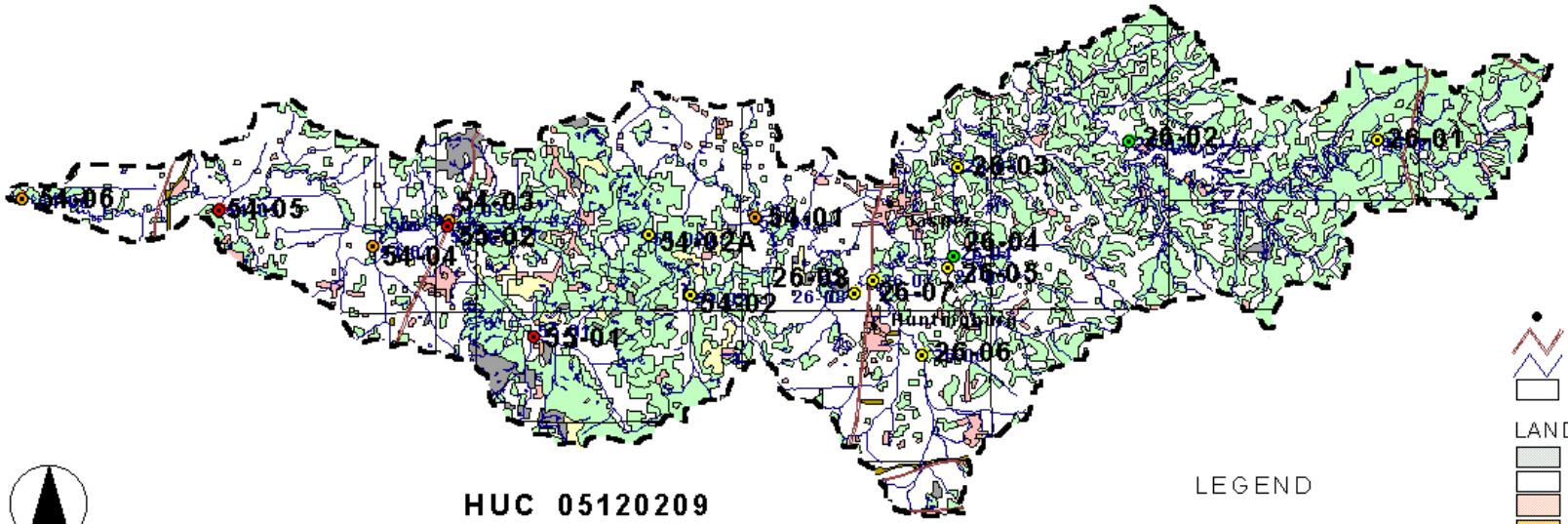
PLATE 2 - Patoka River Watershed, Chloride

Indiana Department of Environmental Management (1998). *Patoka River Basin 1996 Statistical Analysis*by Carl Christensen, MSES. Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Survey Section, Indianapolis, Indiana. IDEM 32/02/000/1998.

Patoka River Watershed

Dissolved Solids (mg/l)



Map Reference

Projection: UTM, Zone 16
Printed: April 1998
Plate Preparation: Joanna Wood

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Assessment Branch/Survey Section

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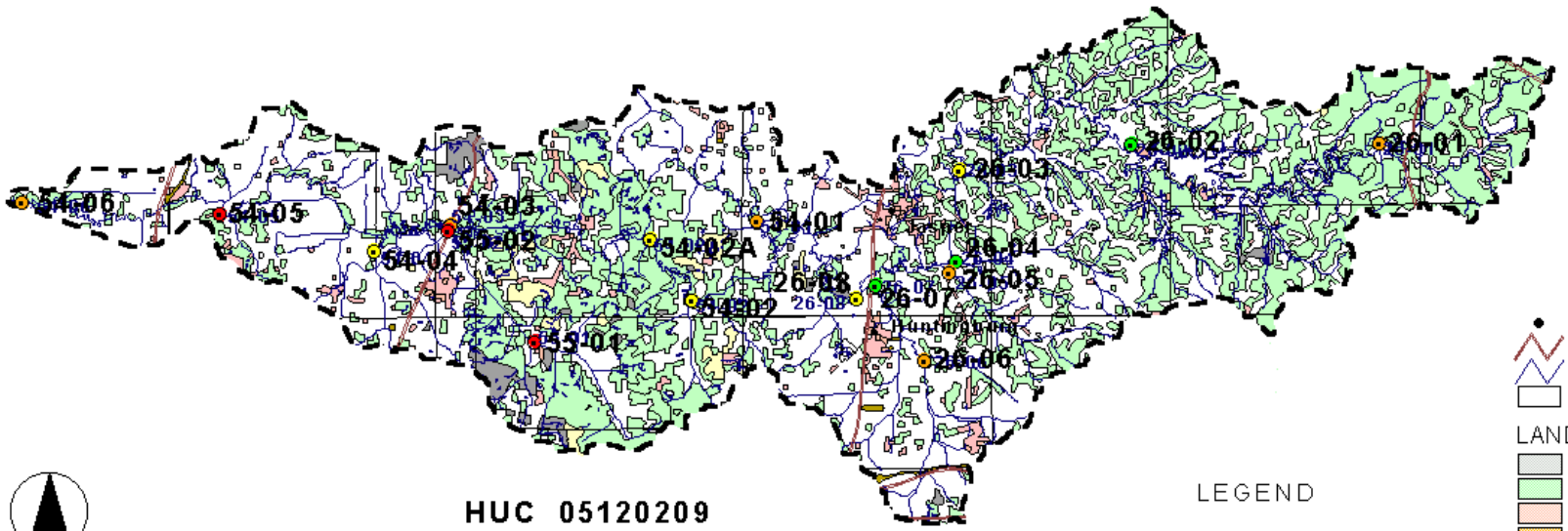
PLATE 3 - Patoka River Watershed, Dissolved Solids

Indiana Department of Environmental Management (1998). *Patoka River Basin 1996 Statistical Analysis*, by Carl Christensen, MSES. Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Survey Section, Indianapolis, Indiana. IDEM 32/02/000/1998.

Patoka River Watershed

Hardness (mg/l)



HUC 05120209

1:375000

5 0 5 10 15 Miles

LEGEND

SAMPLING SITES:
- High
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- Upper Background
- Lower Background

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- Major Roads
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- County Boundaries

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- Residential Land
- Transitional Areas
- Strip Mine Land
- Communication/Utilities/ Transportation

Map Reference
Projection: UTM, Zone 16
Printed: April 1998
Plate Preparation: Joanna Wood

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Assessment Branch/Survey Section

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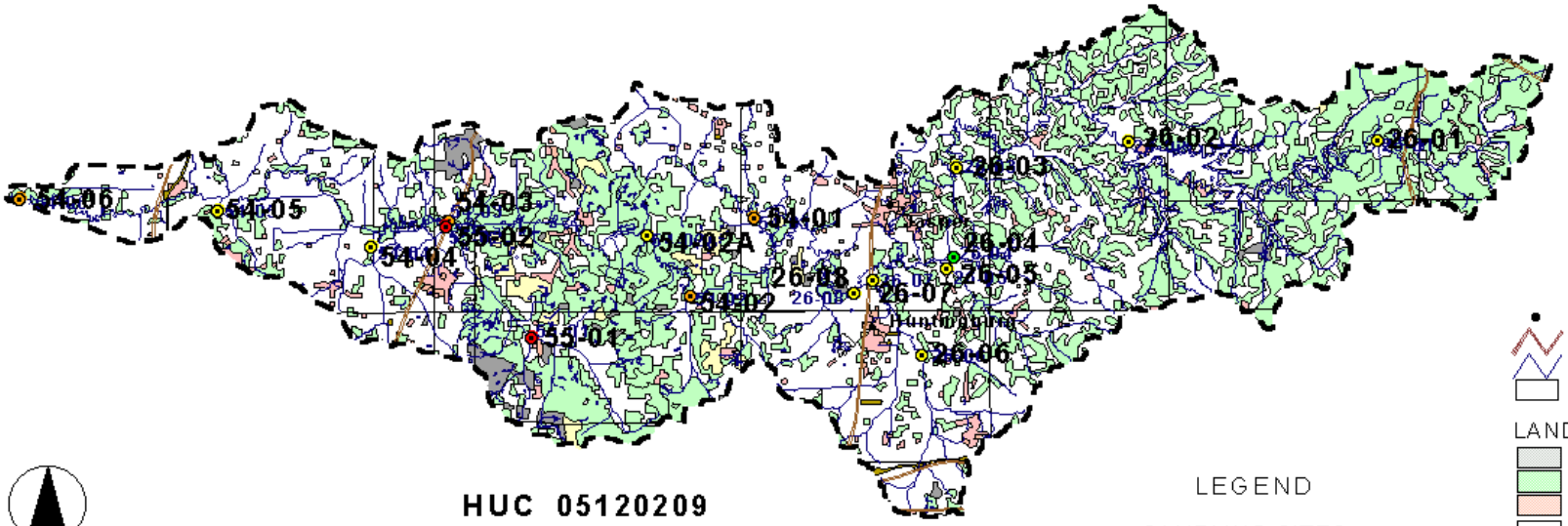
PLATE 4 - Patoka River Watershed, Hardness

Indiana Department of Environmental Management (1998). *Patoka River Basin 1996 Statistical Analysis*, by Carl Christensen, MSES. Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Survey Section, Indianapolis, Indiana. IDEM 32/02/000/1998.

Patoka River Watershed

Sulfate (mg/l)



HUC 05120209

1:375000

5 0 5 10 15 Miles

LEGEND

SAMPLING SITES:
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- Upper Background
- Lower Background

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- Residential Land
- Transitional Areas
- Strip Mine Land
- Communication /Utilities/ Transportation

Map Reference

Projection: UTM, Zone 16
Printed: April 1998
Plate Preparation: Joanna Wood

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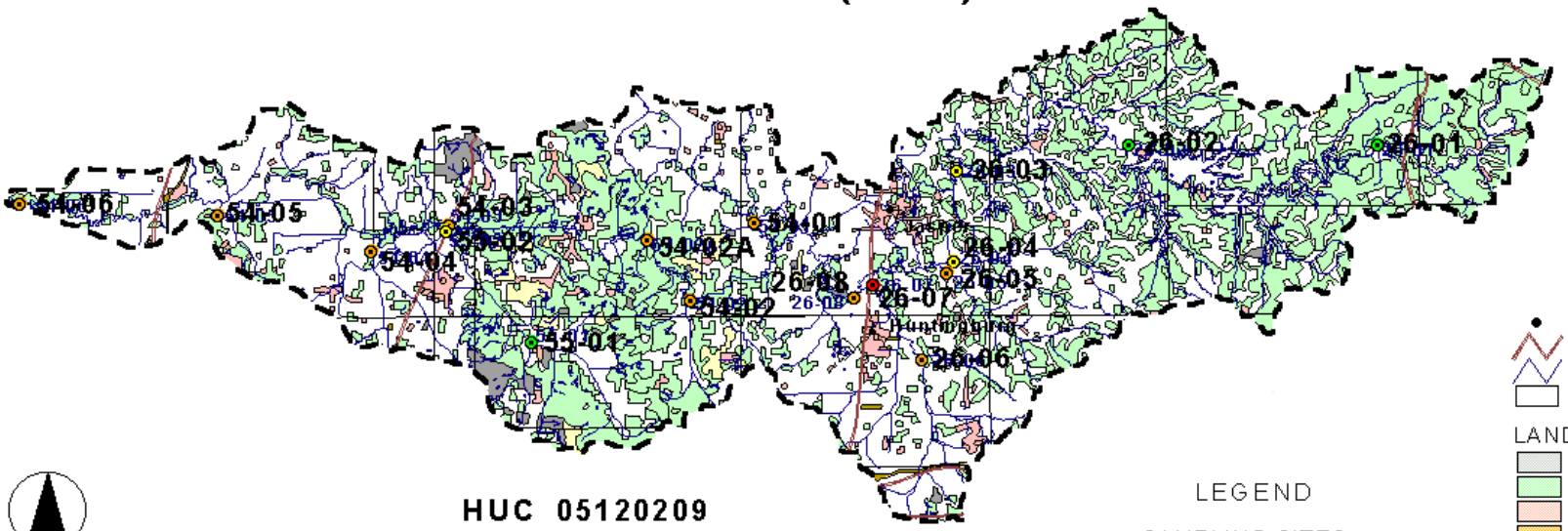
PLATE 5 - Patoka River Watershed, Sulfate

Indiana Department of Environmental Management (1998). *Patoka River Basin 1996 Statistical Analysis*, by Carl Christensen, MSES. Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Survey Section, Indianapolis, Indiana. IDEM 32/02/000/1998.

Patoka River Watershed

Total Kjeldahl Nitrogen (mg/l) (TKN)



Map Reference

Projection: UTM, Zone 16
Printed: April 1998
Plate Preparation: Joanna Wood

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Assessment Branch/Survey Section

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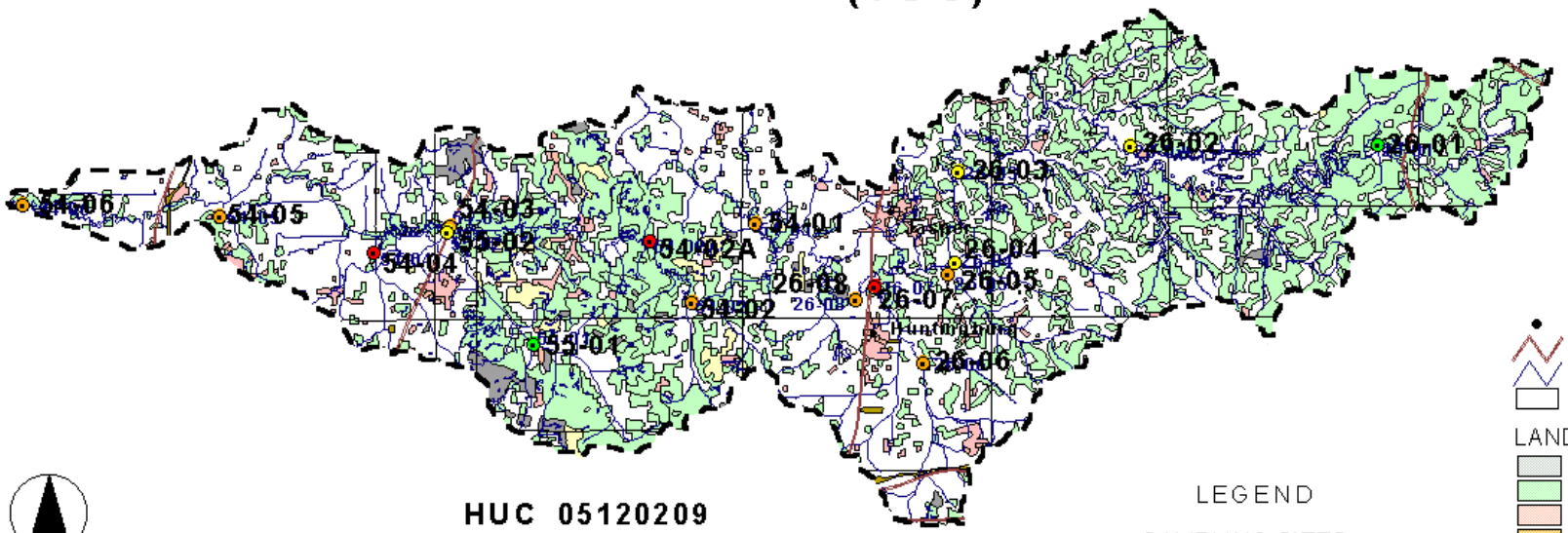
PLATE 6 - Patoka River Watershed, TKN

Indiana Department of Environmental Management (1998). *Patoka River Basin 1996 Statistical Analysis*, by Carl Christensen, MSES. Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Survey Section, Indianapolis, Indiana. IDEM 32/02/000/1998.

Patoka River Watershed

Total Organic Carbon (mg/l)
(TOC)



HUC 05120209

LEGEND

SAMPLING SITES:
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- County Boundaries

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- Residential Land
- Transitional Areas
- Strip Mine Land
- Communication/Utilities/ Transportation

1:375000

5 0 5 10 15 Miles

Map Reference
Projection : UTM, Zone 16
Printed : April 1998
Plate Preparation : Joanna Wood

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Assessment Branch/Survey Section

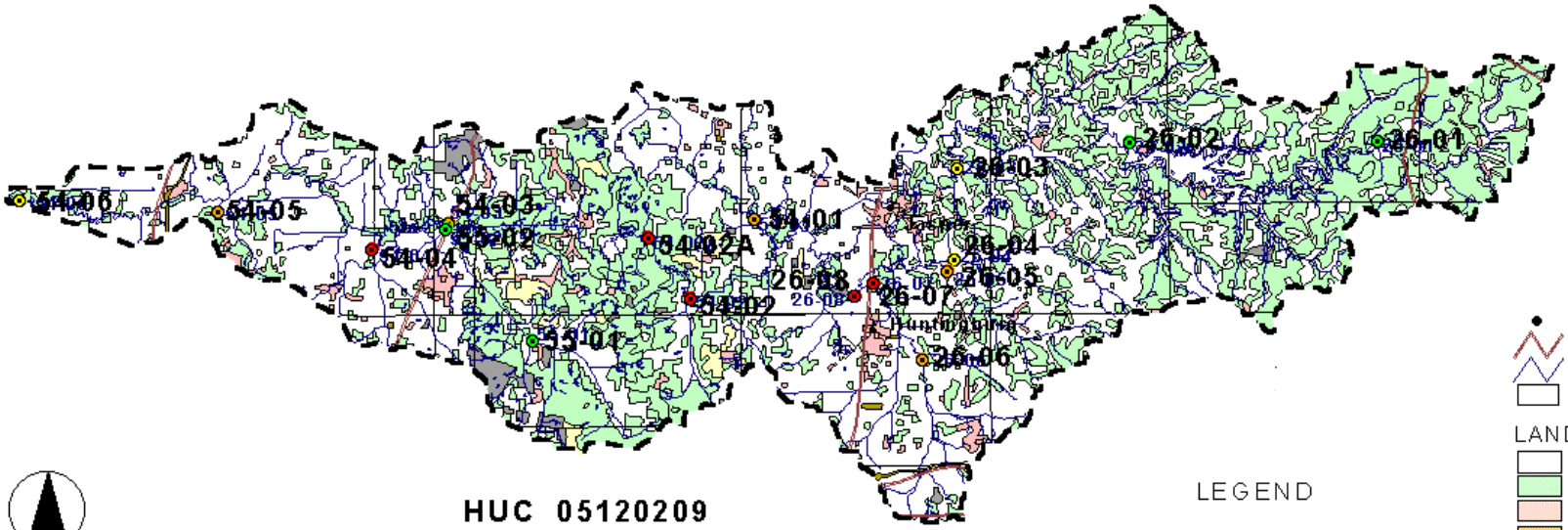
IDEM

PLATE 7 - Patoka River Watershed, TOC

Indiana Department of Environmental Management (1998). *Patoka River Basin 1996 Statistical Analysis*, by Carl Christensen, MSES. Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Survey Section, Indianapolis, Indiana. IDEM 32/02/000/1998.

Patoka River Watershed

Total Phosphorus (mg/l)



HUC 05120209

1:375000

5 0 5 10 15 Miles

LEGEND

SAMPLING SITES:
- High
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- Upper Background
- Lower Background

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Map Reference

Projection: UTM, Zone 16
Printed: April 1998
Plate Preparation: Joanna Wood

IDEM/Office of Water Management
Assessment Branch/Survey Section

IDEM

PLATE 8 - Patoka River Watershed, Total Phosphorus

Indiana Department of Environmental Management (1998). *Patoka River Basin 1996 Statistical Analysis* by Carl Christensen, MSES. Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Survey Section, Indianapolis, Indiana. IDEM 32/02/000/1998.

Patoka River Watershed

Map Reference

Projection: UTM, Zone 16
Printed: May 1998
Plate Preparation: Joanna Wood

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Assessment Branch/Surveys Section

IDEM

Plate 9 - Patoka River Watershed

Indiana Department of Environmental Management (1998). *Patoka River Basin 1996 Statistical Analysis*, by Carl Christensen, MSES. Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Surveys Section, Indianapolis, Indiana. IDEM 32/02/004/1998.